JESUIT ASTRONOMY.

JOHN SCHREIBER, S. J.*

FOR POPULAR ASTRONOMY.

PART I. THE OLD SOCIETY, 1540-1773.

In the following pages I have attempted to jot down a few notes concerning the Jesuits of the 17th and 18th centuries and their relation to astronomy: I say notes, because more than that these lines cannot claim to be; as a long sickness has prevented and still† prevents me from making them more complete, orderly and uniform.

It is certainly a great tribute, redounding to the honor of the Jesuits no less than to the fairmindedness of Professor Förster, Director of the Berlin Observatory, when he says in the *Vierteljahresschrift of the Astronomische Gesellschaft*: "Amongst the members of the Society of Jesus in the past and in the present we find so many excellent astronomers, and in general so many investigators of purest scientific devotion, that it is of important interest to their colleagues in science to notice them etc.."‡

This portrayal by no means claims perfection or completeness for them, but it will probably show that the relation of the old Jesuits to astronomy was very heartfelt, very intimate and well cultivated, and that astronomy was treated in an anything but step-motherly way.

I speak exclusively of the old Jesuits, and understand thereby those who were members of the Society before its suppression. The Society of Jesus was founded in 1540, and was dissolved through the intrigues of the Bourbon courts in 1773. It is self-evident that beginnings were very modest, and the still not-numerous Jesuits so much occupied by their chief work, the application of their zeal to the salvation of souls directly, that scientific labors in the direction mentioned were not to be thought of. Hence the interval in question is narrowed down at best from 1550 until 1800, that is, to about 20 years beyond the Suppression, since many ex-Jesuits, who had received their education in the Society, lived and labored until about that time. Although

* "Die Jesuiten des 17. und 18. Jahrhunderts und ihr Verhältnis zur Astronomie" by Johann Schreiber, S. J., Assistant Astronomer at the Haynald Observatory, Kalocsa, Hungary. *Natur* und *Offenbarung*, Vol. 49, 1903.—Translated by William F. Rigge, S. J., Creighton University Observatory, Omaha, Neb.

† Father Schreiber, the author, died March 10, 1903.

‡ *Vierteljahresschrift der A. G.* 1890, page 60.

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these studies were not their exclusive nor even their principal aim, they have nevertheless during these two and a half centuries been able to do valuable work.

Poggendorff's biographical dictionary of the exact sciences contains in its first two volumes the names of 8,847 savants from remote antiquity until 1863. Amongst these names which embrace many centuries, we find that a little more than 10 per cent are Catholic clergymen, a number by no means to be despised, when one reflects that the rest for the most part, as the notes about them prove, belonged to a profession which obliged them to do something in the exact sciences, such as engineers, professors of physics and mathematics, chemists, hydrographers, nautical men, and the like. And amongst the Catholic clergymen, who have done literary work in the domain of the exact sciences, the Jesuits again number over 45 per cent. So that among the great number of men of all times who have done literary work in the exact sciences, the Jesuits during the short space of 2½ centuries, figure up a very respectable sum, nearly 5 per cent.

It appears from De Backer's Bibliothèque des Ecrivains de la Comp. de Jésus, 1876, and with the aid of its annexed Table méthodique, that 217 authors have done literary work in astronomy specifically. This does not mean that all these productions were very excellent, but at all events it follows necessarily that in the Society of Jesus astronomy had by no means gone to sleep, but had developed a busy life, and as far as matters were destined to go, had blossomed to an ever-increasing extent. We may, of course, lay some stress upon the circumstance that in former times, when, as far as words are concerned, much less learning was required of individuals than today in our age of examinations without number and without end, the knowledge of the principles of astronomy was spread farther and more generally than now;* because almost all of those of the Society of Jesus who were engaged in astronomy, even those who were in any way prominent, took up astronomy so to say, out of private zeal, for they were primarily bound to attend to other functions, for instance, as professors of mathematics, philosophy, theology, or frequently as rectors of important colleges.

Astrology.

At the time that the members of the Society of Jesus began their astronomical activity, the status of astronomy was not well defined. Astronomus, astrologus and mathematicus were

* Dr. *Karl Kostersitz.* Über Bergobservatorien. Vienna, 1901.

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very ambiguous terms. They might mean as well astronomer in our sense, as astrologer in our sense, that is, a savant, or a cheat as well, who has recourse to divination; or again in many cases both, a savant, who, while not exactly intending to deceive, was not able to emancipate himself completely from the views of his age, especially as divination was held in higher repute than true astronomy, and astronomers were in danger of starving to death, if they did not in addition dabble in astrology. This was the condition of affairs at the beginning of the 17th century. The good and great Kepler himself could not entirely escape this danger; he admits it himself: "This Astrology may be indeed a foolish little daughter: but, good God! where would her mother, the highly intelligent Astronomy remain, if she did not have this silly daughter. * * * And the Mathematicorum salaria are so meager that the mother would surely suffer hunger, if the daughter did not earn anything."

At all events Kepler seemed really to believe in astrology to some extent and not to indulge in pure deceit. Thus he once wrote a letter to Fathers N. Serrarius and J. Ziegler in Mayence, October 18, 1606; he sent them a work he intended to publish, and asked them for their opinion (for the Protestant Kepler was upon the best terms with the Jesuits) and said they should speak out their minds freely, he was not so sensitive * * *, at most they might pick a slight quarrel with him on account of astrology, but he believed that he was yet within the limits of the permissible.

In this weakness he had yet many models and colleagues of high-sounding names, such as Nostradamus, Regiomontanus, Stöfler, Melanchthon, etc.

With this astrology, the separation and removal of which from astronomy, was assuredly itself a meritorious work, the Jesuits were by no means on good terms. Already in 1591 Father Benedict Perrerius made a vigorous attack upon it. He wrote a work on the different kinds of superstitions, and very particularly "de divinatione astrologica." It went through five editions. In like manner Fr. Alexander de Angelis "In Astrologos conjectores" libri 5. Romæ, 1604. In the year 1676 the 7th edition entered upon the field. Fathers Roberti, Renaud, Pinamonti, Noceti, did similar work. Fr. Nicolas Caussin in 1649 published in the press a letter to a "personne illustre sur le curiosité des Horoscopes." The horoscope, that is, divining the character of a person from the positions of the stars at his birth, in other words, predicting —or mendaciously fabricating—his future fortunes, was,—I am

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using the words of the Zürich Professor Wolf—"from the beginning a pure fraud and one most known to deceive," but one altogether indispensible to "personnes illustres." I draw attention only to Rudolph II, Wallenstein, Gustavus Adolphus, Catherine de Medici—; the 16th and 17th centuries could not exist without the noble art, astrology, so that Father Riccioli, in his famous work, the Almagest (I, 21) could say as late as the year 1651, that such people would always be found, and with Tacitus call them genus hominum "quod semper in Urbe vetabitur et semper retinebitur," only, he says, it ought to read in Orbe.* The fight against this superstition was certainly a deserving work.

Observatories.

The predilection for astronomy in the Society of Jesus stands out most clearly in the erection of observatories. I say, in the Society of Jesus—and truly as such; for this is not the affair of one man, let alone that of individual members of an Order not one of whom can dispose of a cent. Now the Society of Jesus has not only itself during its comparatively short existence erected a very considerable number of observatories, but was also in a condition to accept some of those that had been erected at government expense and to man them with appropriate talent.

Of course, the first observatories in which the Jesuits did work, were not observatories in the modern sense; this is true in general in regard to all the observatories of that time; they were only modest beginnings. There were proper sites, some necessary instruments, that were probably completed in course of time, some observers, and industry and zeal for science.

The first greater observatory which was fitted out by the Jesuits, was a government one,—built at the expense of the Celestial Kingdom,—in Peking, where astronomy had for ages past been held in high esteem, of course, more on the score of utility, in order to seek advice in all possible transactions, even the most intricate affairs of state, advice which the stars gave gratis very willingly, through speaking tubes, however, that did not always furnish their interpretation according to eternal laws. Nevertheless, we are indebted to the citizens of the Celestial Kingdom for

* v. Littrow says in his "Wunder des Himmels" (1886, p. 604), where he treats of these absurd things: "Whoever takes pleasure in these fairy tales, can find them in the works of the well-known Jesuit Riccioli (Almagestum novum)." Yes, certainly, but Riccioli communicates them "exaliorum magis quam Nostra opinione," and concludes thus: "Jam enim me taedet, in incerte Astrologorum pulvere lusum prolixiorem ludere," that is, it disgusts me to continue such low play. May this serve to complete, if not to correct, v. Littrow.

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many very ancient, perhaps the oldest, observations. When the Jesuits were directing their steps towards China, astronomical knowledge was, of course, in a sorry plight, and it was time for a thorough reform. The intelligent emperor Cham-Hi then transferred the superintendency of the heavens to the Jesuits, their first task being to cut off with technical exactitude the cue of the Chinese astronomers which hung down heavily behind, and to offer them European fashions instead. It was a piquant coincidence, that contemporaneouslv with the erection of the Paris Observatory, Father Verbiest S. J. in Peking, in the Kingdom of the Centre, was equipping a sister institution in up-to-date European scientific style (1668). This observatory is the fourth of its kind of government institutions, as only the observatories of Leyden (1632), Copenhagen (1637) and Paris (1667) antedate the time of its erection. Fr. Verbiest was therefore the first director of the observatory, styled in Chinese the President of the Mathematical Tribunal, and from that time until the death of Fr. Hallerstein in 1774 a Jesuit always filled this position.

In order then to indicate briefly the activity of the Jesuits at this observatory, let me cite the passage from De la Lande's *Astronomia* (p. XXXIX) referring to it: "This observatory was not at all unprofitable; a great many good observations were made there, of which Fr. Gouye, in 1688 and 1692, published a part; and again Fr. Souciet a part in 1732; many of them also are to be found in the manuscripts of Mons. de l'Job. The Fathers Fontaney, Ricci, Gautil, Benoît, Jacque, Kegler, and Slaviczeck and many other Jesuits have distinguished themselves there." And in the *Memorias de Mathematica et Physica da Academia R. das sciencias de Lisboa*, Tom. II 1799, "Eclipses and occultations observed in Peking from 1753 until 1795 by Andreas Rodriguez." In like manner Hell in Vienna published in 1768 "Observat. astr. ab Anno 1717 ad annum 1752 Pekini Sinarum factæ etc."

Government Observatories.

Among the government observatories conducted by the Jesuits the following must also be mentioned:

Vienna. An observatory was erected there in 1745 as an annex to the university, but completed only in 1756. This was the beginning of the present university observatory. For it was reconstructed in 1820-1826 and in 1879 transferred to the Türkenschanze. A small observatory had indeed already existed in the Collegium Academicum since 1735 under the direction of Fr. Franz, but while a public one, it did not have the title of a uni-

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versity observatory. The directors were Father Hell, 1745, and Father Triesnecker, 1792.

Wilna. The university observatory was founded in 1753. Fr. Poczobut restored it and completed the instrumental equipment, was appointed its director, and remained even after the Suppression in the same position and with the same staff of observers, as the most of them were ex-Jesuits.

Schwetzingen 1764 and *Maunheim* 1772. Built by the Elector Theodore of Palatine; Fathers Christian Mayer and John Metzger especially worked there.

Private Observatories.

Outside of these government institutions the Jesuits possessed also many observatories erected with their own funds. I mention only the most prominent.

Marseilles. In 1702 the Jesuit college of S. Croix erected a small observatory, at which amongst others Fr. Lavel and later Fr. Pézénas observed. Fr. Pezenas equipped it richly with instruments, mostly at his own cost, and obtained a pension from the queen in order to support two Jesuits as assistants. He himself was director until the Suppression of the Society. This scientific institution was taken in charge by the Administration of Marine in 1749, but the Jesuits remained there.

Lisbon (1722). Founded in the college of St. Anthony, it was taken in charge by the government in the year 1728, and transferred to the royal palace. The first director was Fr. Carbone S. J.

Prague. The modest observatory existing already was completed by Fr. Jos. Stepling, and equipped by him with new instruments at the expense of the Bohemian Province of the Society of Jesus; in 1761 Fr. Stepling also devoted to the observatory the inheritance of 4,000 florins coming to him after his mother's death. He increased the library of the Clementinum (so the enormous College of Prague was called) by about 600 of the best mathematical works, so much so that a section was called the "Mathematical Library." He directed this observatory from 1751 until his death in 1778. After the Suppression it became and is still the government university observatory.

Vienna. At first the beginning of an observatory existed under the title of "Mathematical Cabinet," in the erection of which the greatest credit is due to Fr. Ernest Vols. He died in 1720. The academic college possessed some instruments since 1735, which were used by Fr. Franz. This private observatory still continued

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after the erection of the university observatory in 1745. Fathers Liesganig, Pilgram and others were especially prominent at this observatory.

Milan. Fr. Pascal Bovio and Fr. Dom. Guerra, professors of philosophy in the college of Brera, erected in 1760 an achromatic telescope of 40 feet focus, and also an armillary sphere and a pendulum clock, and thus founded an institution which must be considered as the origin of the present observatory (Obs. di Milano). The need of finer measuring instruments was soon seen, and the rector of the college, Fr. Pallavicini, a man very enthusiastic for science and himself very learned, provided some instruments. In 1762 Fr. Lagrange, already renowned through his labors in Marseilles, became director. Then Fr. Boscovich, called by the senate of Milan to be professor of mathematics at the Pavia university, came to Milan, managed the erection of a more suitable observatory, and acted for a while as director. After him came Fr. Lagrange again. The Jesuits had spent 60,000 livres on the observatory.

Florence. Fr. Leonhard Ximenes, who had won great renown for himself especially in hydraulics, was commissioned by the emperor to settle the boundary difficulties between Toscana and Lucca. No question in hydraulics was treated in Italy without being submitted to him. He applied the means coming to him from his father's fortune and his own various official positions, to adorn Florence with a scientific institution. He founded the observatory of S. Giovannino, renowned for its great mural quadrant and the famous gnomon of Toscanelli, which Ximenes restored. He added an excellent library and a large number of instruments. After a pious and laborious life he died at the age of 70 years in 1786. In his will he founded two professors' chairs, one for astronomy, and the other for hydraulics, which were to be filled by two Piarist religious priests, to whom he also deeded his library and his cabinet.

Rome. "Observatorio di Collegio Romano,"—which however no longer belongs to the Roman College, but along with all its valuable instruments was acquired by the government in 1870 in a very profitable and cheap way, that is, was declared to be government property, an act which, of course, settled the question of justice. The beginnings of this observatory date far back. The buildings of the Roman College which were erected in succession at various times, have for a long time back given shelter to astronomical instruments. In the old Roman College Fr. Scheiner gathered the material for his chief work Rosa Ursina, in which he

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exhaustively treats of the science of the Sun as known in his time, and used there the first telescope mounted equatorially. The same building saw the labors of Fr. Clavius, who observed with a zenith sector as early as 1572, of Fathers Grienberger, Gottigales, Asclepi, Borgondi, Boscovich, and many others. A more suitable place was being projected for the observatory, but the Suppression of the Society put an end to these plans. In 1824 the observatory was again given over to the Society, and under de Vico, Sestini and Secchi it became a modern observatory equipped with the best instruments, at the expense partly of the Society, and partly of the private means of Piux IX. But this date already transcends the time limits marked out in this paper.

Parma. In 1757 Fr. Belgrade allowed one of the two towers of the college in Parma to be changed into an astronomical observatory.

Pout-à-Mousson was provided with a good observatory and equipped with very good instruments. Here amongst others Fr. Collas, who went to India in 1767, and Fr. Barlet, observed a partial eclipse of the Sun, which the Paris astronomers had neither predicted nor announced. The details of this observation were given in all the papers of that time.

Graz. The new building of the astronomical observatory was begun in 1745: the college contributing 7,000 and the Provincial of the Order 2,000 florins. The Jesuits did very much for this observatory, as for instance, establishing a special fund for its maintenance, which amounted already to 4,300 florins in 1773. Here Fr. Liesganig determined the meridian of Graz, Fr. Tirnberger discovered the comet in 1769, and Frs. Bode and Biwald worked. Things went on in this way until the Suppression of the Society, and then?— Then it was judged proper to do away with the chair of astronomy, to lock the observatory, to give over the capital to the students' fund, and at the very end in 1787 to tear down the mathematical tower—under the plea of "unnecessary."

Lemberg. Von Zach, who was by no means a special friend of the Jesuits, writes in regard to the Lemberg Observatory:* "It is a pity that at a time, when the science of the stars is obtaining new protectors and warm promoters in all countries, already existing institutions, which might advance this science, should go to ruin or be neglected. While the Order of Jesuits was still in existence, the Lemberg College had in connection an observatory which was pretty well provided with various astronomical in-

* Monatl. Korrespondenz von v. Zach, Nov. 1801, p. 547.

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struments. * * * Later on this astronomical tower was entirely demolished, so that no trace of it is left any more. * * * There was no dearth of pendulum clocks, and amongst them a fine English one by Graham. * * * These clocks are scattered amongst the various professors and serve as ornaments to their rooms."

Tyrnan. The observatory in Tyrnan in Hungary was erected in the years 1753-1755 in the great college there with which the university (now in Budapest) was connected. The observatory was 110 feet high, the observing tower attached to the building 18 feet high, 56 feet long on the longer side and 40 feet wide on the shorter, and provided with an underground space 12 feet deep, which was intended especially for the comparisons of the baroscope and thermoscope above and below. It was built under the direction of Fr. Francis Weiss, who was appointed the director, his assistants being Fr. John Sajnovits and Fr. Francis Taucher. At the time of the Suppression of the Society the observatory had a small fund of 2,290 florins; at the Suppression things were managed with greater forbearance than they were for instance in Graz and Lemberg, as the government desired the observatory to continue, and even promised to defray out of the university treasury what was necessary over and above the 120 florins of the interest of the above capital. Of course, the confiscated property of the Jesuits was more than sufficient for this purpose. Fr. Weiss remained the director and professor of astronomy at the university, the former assistant at the observatory remained in his position with a salary of 600 florins. Fr. Weiss' (1717-1785) astronomical observations and treatises had spread his name in astronomical circles even in foreign countries, according to the assurances of the royal commissaries in 1774. He was also invited by the Elector to the Mannheim Observatory, but he declined.

This would finish the enumeration of the most prominent observatories; for there were others also of lesser importance concerning which I could not get more particulars, as Breslau, Olmütz, Ingolstadt, Dillingen, Toulon and others.

Astronomical Inventions.

Let this suffice for the observatories. Now only a few words about three contrivances which figure very prominently even at present in all observatories, and which owe their existence to three Jesuits. The first is the vernier. Probably not a single astronomical angle-measuring instrument, not a theodolite, not a

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universal instrument, not an equatorial, is to be found unprovided with verniers. It consists essentially of two scales, moving upon one another, and so arranged that when one of them, for instance, is divided into degrees, the other has 10 divisions corresponding to 9 degrees of the first, and in this way reads to tenths of a degree. The inventor is Fr. Christopher Clavius. (Famous mathematician, died 1612 in Rome).

Brensing writes as follows in his article "Nonius or Vernier" in the *Astronomische Nachrichten:** "Clavius has been forgotten or neglected in an unintelligible way; I was surprised when I came upon the following passages in his works (Christophori Clavii Bambergensis opera, Moguntio 1611):" —he cites in full—; and then continues: "These passages give the clearest proof that we are indebted to no other than Clavius for the theory of vernier subdivision, as well for linear as for circular measurements. They have been overlooked." Professor Wolf of Zurich thinks that this contrivance should be called neither Nonius, nor Vernier, (the assigned inventors) but rather Clavius.

The second contrivance to be found in all observatories is the equatorial mounting of the telescopes, which, when they are of a certain size, are then simply called equatorials. The arrangement consists in turning the telescope about an axis which is parallel to that of the Earth, so that when the telescope is perpendicular to this axis it moves in the plane of the equator, when it is turned up or down, it always moves in parallel circles, thus enabling one always to keep a star in the field of view without difficulty, when once the tube has been set upon it. The invention of this important contrivance is derived from the Tyrolese Father Christopher Grienberger (died 1636 in Rome). Fr. Christopher Scheiner says in his chief work, Rosa Ursina, p. 352, that Fr. Grienberger endeavored to invent this mounting for the special purpose of making daylight observation of stars possible. The first observation with this kind of mounting of which we can find a record, was made on March 4, 1627, by Fr. Scheiner, who used it for his solar observations, "because, he says, although Fr. Grienberger has lately constructed this machine for other purposes, it is specially suited for my work." He adds also that he describes the machine "because, as it seems, the inventor of this instrument will not do it himself." Thanks therefore to Fr. Scheiner that it was not forgotten on account of the modesty of the inventor, or connected with another name, as happened to the vernier of Fr. Clavius

* *Astr. Nach.* Vol. 96, p. 131.

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which was brought to light and ascribed to its inventor only after 270 years.

But Fr. Scheiner also here deserves a mention. I will not speak of his inventing the pantograph, so generally used today, and that too in both of its styles, because it does not strictly belong to astronomy. It has been proved that in order the better to observe sun-spots he constructed the first *astronomical* telescope, that is, one consisting of convex glasses exclusively in opposition to the only one hitherto used, called the Dutch telescope, which had both convex and concave glasses (1613), the advantages of his being such that it later on almost entirely superceded the Dutch telescope.

The idea of the reflecting telescope also comes from a Jesuit. The thought of replacing the objective lens by a mirror was announced as early as 1606 by Fr. Nicolas Zucchi (Parma 1586—Rome 1670), and carried out at least in so far that he took the image made by a concave mirror and examined it with a concave lens.

Another important invention, which I would put down as the third, and which is continually being used even at present, especially in observing comets or other such objects which do not admit of artificial illumination in the field of view of the micrometer of the telescope, was the happy idea of Fr. Roger Joseph Boscovich (Ragusa 1711—Milan 1787) of using the circular field formed by the last diaphragm in the telescope as a micrometer—called a ring micrometer. The ring micrometer is often ascribed to Huygens, but, as Wolf* shows, falsely so. The field of view of the telescope was, of course, being used for measuring the diameters of the planets, a method which appears already in Fr. Scheiner; Huygens added a contrivance to this to facilitate this measurement. But this was no ring micrometer in the present sense, by means of which the difference of position of two stars is computed from the times of their ingress and egress. It was an occasion of the comet of 1739 that Boscovich showed it was exactly in comparing such an object, which scarcely admitted of a field illumination, with a neighboring star, that the observation of the times of entering and leaving the field of view of the telescope furnished the data for computing the difference of right ascension and declination, and he developed the appropriate theory. This ring micrometer was later on fitted up by Frauenhofer in excellent shape, so much so that now it occupies a place among

* Wolf, *Handbuch*, Vol. II, p. 128.

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the instruments of precision of every observatory, and in the observation of comets it is used almost exclusively.

(TO BE CONTINUED.)

THE CREIGHTON OBSERVATORY, OMAHA, Neb.

THE RELATION OF THE MASS OF THE UNIVERSE TO STELLAR DYNAMICS.

LUIGI D' AURIA.

FOR POPULAR ASTRONOMY.

Supposing the stars to be scattered without any great and well-marked deviation from uniformity and to constitute a system approaching the form of a sphere of some finite radius ρ, the acceleration or retardation upon any one of the stars caused by the mass M of the *ensemble* would not differ much from that produced upon a material point occupying the place of the star by a sphere of gravitational medium of radius ρ and uniform density

$$\sigma = \frac{M}{\frac{4}{3}\pi\rho^3} \qquad (1)$$

In other words, on this supposition, we could study the dynamics of the stars by considering these bodies as material points moving in a hypothetic uniform medium having for density the value of σ given above.

In a paper entitled "Stellar Dynamics," read May 13, 1897, before the American Philosophical Society of Philadelphia, published in the *Journal of the Franklin Institute*, Oct., 1897, I showed that the acceleration of a body contained within a sphere of gravitational medium of uniform density σ, at any distance x from the center of this sphere, would be

$$\phi = g\frac{\sigma x}{RD} \qquad (2)$$

in which R and D are the mean radius and the mean density of the Earth, and g is the mean gravitative acceleration at the Earth's surface. In this paper the effect of the mass of the stars was neglected, that is, the stars were considered simply as material points attracted by a sphere of gravitational medium of uniform density σ extending to the boundary of the stellar universe, and it was shown that, if devoid of angular motion, a star under these conditions would oscillate in a straight line passing through the center of this sphere with velocity

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notice of this popular work. It will suffice to say that Professor W. H. Pickering has made a most valuable and timely contribution to the literature of the Moon, by the aid of the best modern methods of research. The fact that the book has been written entirely in popular language is one of the best things about it. Intelligent popular readers will find it the best reference book for late knowledge of the Moon in connection with any good text-book on the subject that we know of.

The author calls our attention to the following errata:

Page 32, line 31, for 5.7 read 5.6. Page 37, line 18, for (64,159) read (2.5, 6.3). Page 37, line 25, Plate 3B is inverted. These measures should therefore be made from the left and top. Page 37, line 29, for 6.3 read 6.2. Page 37, line 31, for 6.6 read 6.5. Page 39, line 5, for 4.1 read 4.2. Page 43, line 16, for 8 read 8. Page 49, line 19, for B read C. Page 49, line 25, for Messier, A read Messier A. Page 52, line 2, see page 37, line 25, above. Plate F. The straight dark lines on Figures 6 and 7 are defects. Figure 7 should be turned one-quarter way round, so as to resemble Figure 8. Page 68, line 18, for 33, read 13. Page 70, line 27, for 3B (1.2, 8.5) and 3E (1.1, 8.6) read 2A (3.2, 2) and 2C (3.2, 1.8). Page 70, line 28, for 5 and 8 read 3 and 6. Plate H, last line, for 22 read 2. Page 103, line 1, for contents read constants. Plate 3B. This plate is inverted.

JESUIT ASTRONOMY.* II.

JOHN SCHREIBER, S. J.†

FOR POPULAR ASTRONOMY.

Observations.

If we ask what the Jesuits have observed, the self-evident answer is: Very much. This is warranted by the many publications in which the current observations are communicated. Thus, for example, Fr. Maximilian Hell in Vienna edited the ephemerides from 1757 until 1795, and Fr. Triesnecker from 1794 until 1806. These, besides the numerical which is the essential, but at the same time the most laborious part of the ephemerides, alway contain an appendix of the observations made in the course of the year. Besides these Hell also issued about thirty separate publications, Triesnecker 7.—The like is true of Fr. Francis Weiss in Tyrnau, who published the observations from

* Continued from page 20.

† "Die Jesuiten des 17. und 18. Jahrhunderts und ihr Verhältnis zur Astronomie" by Johann Schreiber, S. J., Assistant Astronomer at the Haynald Observatory, Kalocsa, Hungary. *Natur* und *Offenbarung*, Vol. 49, 1903.—Translated by William F. Rigge, S. J., Creighton University Observatory, Omaha, Neb.

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1756 to 1770; the last years being by Fr. Francis Taucher. For the rest a glance at Riccioli's Almagest is sufficient to show what a busy life the Jesuit astronomers lived. Where he speaks of eclipses, for instance, he mentions very many Jesuits who took part in the observations, and gives the manner of observing used by each and the result. In order to give prominence to only one eclipse: for the lunar eclipse of April 14, 1642, he mentions the following places (I omit the names and remarks): Mantua, Trieste, Bologna, Paris, Cologne, Paderborn, Würzburg, Ingolstadt, Eichstädt, Prague, Glatz, Neisse, Canada.—The eclipse of November 8, 1612, is also interesting. It was observed by Blessed Charles Spinola at Nangasacki; Fr. Julius de Alenis at Macao, Fr. Uremanns at the same place, Fr. Scheiner in Ingolstadt.

The transit of Venus of 1761 was observed* at Vienna by Fathers Hell, Liesganig, Steinkellner, Mastalier and Richtenburg, at Madrid by Fr. Rieger and others, at Florence by Fr. Ximenes, at Ingolstadt by Fr. Kratz, at Würzburg by Fr. Huberti and others, at Schwetzingen by Fr. Mayr, at Dillingen by Fr. Hauser, at Laibach by Fr. Schöttl, at Tyrnau by Fr. Weiss.

These current observations, however, are just the business of every observatory and of every astronomer.—I will therefore give prominence only to those observations which were either very excellent or the first to be instituted in any one direction, or otherwise very remarkable, and in their enumeration I will keep to the customary classification of the Sun, the Moon, and the Stars.

The Sun.

To begin with the Sun, the first place not only among Jesuit astronomers, but among all old astronomers, is due to Fr. Christopher Scheiner. I say the first place, because he was by all odds the first to occupy himself thoroughly for many years with the Sun; because he was the first to arrive at results which have value even today, and of which it is not at all certain that they have really been improved upon.

Fr. Christopher Scheiner (born in Suabia 1573, died in Neisse 1650) had already in presence of his pupil Cysatus discovered sun-spots in March, 1611, and from that time on had observed them uninterruptedly, and indeed in order to make sure of the matter, had organized a whole corps of solar observers, all Jesuits, to observe simultaneously with himself: Fr. J. B. Cysatus

* De Backer.—Title "Hell." [*Cfr. Astr. Papers of Amer. Ephem.* Vol. II.]

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in Ingolstadt and afterwards also in other places, Fr. Chrysostom Gall in Lisbon, Fr. George Schönberger in Freiberg, Fr. Joseph Biancani in Parma, Fr. Caspar Ruess in the West Indies, Fr. Charles Malapertius in Belgium, and others. In the year 1631 he published his great work under the title Rosa Ursina, in which his observations are given and illustrated with very good drawings. The principal result of his researches is the determination of the elements of the Sun's rotation, that is, the inclination of the axis toward the ecliptic, the longitude of the ascending node and the time of rotation, performances which are indeed duly acknowledged in almost all astronomical text books. But the rest of the contents of the great folio volume is less known—and it is not less interesting. It is to be remarked that the telescope was invented in 1608 and that the tube with which Scheiner made his last observations, in about 1625, could not have been an excellent instrument, as well on account of lack of achromatism, as certainly also on account of want of proper polish and the smallness of the objective. At all events Scheiner is none the worse for his instrument, speaks often of its extraordinary performing power—because he happened to know nothing better. The principal reason of his seeing so much and such delicate things, that one is forced to wonder at it, must probably have been due to his skill, since he adopted various ways to protect himself against delusion and to insure the true facts of his observations.—Thus he was the first to apply the so-called dark glasses that are now used generally, and the first to invent the artifice of diaphragming the objective. In short, in the handling of the telescope he was perfectly at home, even the distortion caused by the objective did not escape him when he projected the Sun's image upon paper, which was his usual method of observing.

Now, Scheiner has established so many and such delicate facts with this telescope, that we can boldly maintain that, except for spectroscopy and photography, solar researches have not yielded anything new that is not already to be found in Scheiner's observations, as the astronomer Winecke declares* when he says: "In his Rosa Ursina truths are established that have been forgotten because the earlier observer was wantonly set aside, and the same had to be discovered anew not long ago." In order then briefly to indicate the most important things, the granulation was already known to him, no less than the veiled spots; although he does not use the word, which they did not yet

* Vierteljahresschrift d. Astr. Ges. 1878.

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exist, his description of these phenomena is so clear and unmistakable that no doubt is possible about the matter. He has very thoroughly examined the formation and dissolution of the spots; and he treats in a masterly way the question which even today is much discussed, whether the spots are depressions. He proves himself possessed of a knowledge which was very advanced for that time, inasmuch as he establishes the proper motion of the spots in longitude and latitude, no less than the frequently eccentric position of the penumbra, and the more exuberant and solid development of the spots and faculæ at the Sun's preceding limb. The word faculæ comes from him. He had formed ideas about the physical constitution of the Sun very like those of today, and he even surmised the interior of the Sun, the nucleus or kernel, to have a rotational velocity different from that of the outer shell.*

The Moon.

The Moon was studied in a thorough manner by Fathers J. B. Riccioli and Fr. M. Grimaldi,—or as v. Littrow in his "Wunder des Himmels" expresses himself in a somewhat queer fashion, "the well known Jesuit Riccioli has occupied himself very much with the Moon and with the whole of astronomy generally, without, however, thereby advancing this science very much." We shall see later that this view is not shared by others. I have shown elsewhere† that v. Littrow's notice, which begins with the above words, and with which he makes fun of Riccioli's lunar nomenclature, is false in all its details and only proves that v. Littrow was very poorly informed in lunar affairs. Now, Riccioli has introduced the lunar nomenclature which is in use even today, and in a very systematic, but hitherto entirely overlooked manner, has very much lessened the labor of the memory in locating the lunar formations. But his colaborer Grimaldi drew up one of the first maps of the Moon worthy of the name. The first was the map of Langren of 1645, then the one of John Hevelius followed in 1647. In the year 1651 Fr. Riccioli published in his "Almagest" the map of the Moon that Grimaldi had designed and drawn from his own observations. Edmund Neison, the renowned lunar topographist of the present day, makes the

* [For further information the reader is referred to "P. Christoph Scheiner, S. J. und seine Sonnenbeobachtungen" by the same author, *Natur* und *Offenbarung*, Vol. 48.]

† Die Mondnomenklatur Riccioli's und die Grimaldische Mondkarte, Stimmen aus Maria-Laach. Freiburg i. Br. 1898, Pamphlet 3.

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following remark about this map.* "Riccioli, although an inferior observer to Hevelius, has had the merits of his map much underestimated; for it appears to have been the result of good lunar observations, and is in some particulars superior in completeness and accuracy even to Hevelius's, though from his less exact estimates of distances it is less so on the whole. But his labors have afforded results far superior to what would have been expected from the disparaging observations of Beer and Mädler. In his remarks as to the probable nature of the surface Riccioli is juster than most of his immediate successors." Riccioli and Grimaldi have in addition occupied themselves much with observations of the libration, so that Riccioli himself says that Grimaldi's observations of the libration, when gathered together, would make a good-sized book. Both carried on a lively expistolary correspondence with Hevelius.

The Stars.

In the realm of the stars also the Jesuits have done some meritorious work.—To begin with the planets, it is to be noted that Fr. John B. Zupi was the first to discover the dark stripes or bands that are to be found on Jupiter. In regard to Saturn (already before Huygen's time) a determination of Grimaldi's† which gave Saturn the nearly correct oblateness of 1-12 was about the only certain result. The phases of Mercury, which Galileo surmised more than saw, were first seen by Fr. John B. Zupus in Naples on May 23, 1639, and repeatedly afterwards; he also furnished accurate drawings.

An epoch-making discovery in the domain of the fixed stars, which was at first misunderstood, but which continually found more recognition, is due to Fr. Christian Mayer, astronomer at the Mannheim observatory. Humboldt pronounces in a very acceptable way about it‡: "Christian Mayer, the Mannheim astronomer, has the great merit of having first (1778) made the fixed stars a special object of research, by the sure method of actual observations. The unfortunate choice of the term *satellites of the fixed stars*, * * * exposed him to bitter attacks from his contemporaries * * * That dark planetary bodies should become visible by reflected light, at such an immense distance, was certainly improbable. No value was set upon the results of his carefully conducted observations, because

* Neison, The Moon, London, 1876, p. 87.

† Wolf, Handbuch II, 470.

‡ Humboldt, Cosmos, Otté's translation, London 1851, vol. 3, p. 275.

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his theory of the phenomena was rejected; and yet Christian Mayer, in his rejoinder to the attack of Father Maximilian Hell, Director of the Imperial Observatory at Vienna, expressly asserts "that the smaller stars, which are so near the larger, are either illuminated, naturally dark planets, or that both of these cosmical bodies—the principal star and its companion*—are self luminous Suns revolving round each other." The importance of Christian Mayer's labors has, long after his death, been thankfully and publicly acknowledged by Struve and Mädler. In his two treatises, *Vertheidigung neuer Beobachtungen von Fixsterntrabanten* (1778), and *Dissertatio de novis in Coelo sidereo Phaenomenis* (1779), eighty double stars are described as observed by him, of which sixty-seven are less than 32″ distant from each other. Most of these were first discovered by Christian Mayer himself, by means of the excellent eight-foot telescope of the Mannheim Mural Quadrant; "many even now constitute very difficult objects of observation."

The duplicity of many stars was, of course, known before, but no concern was shown as to whether they were optical or physical pairs; this was first rendered possible by measurements, of which Fr. Christian Mayer made the beginning, and which are even now or only just now being continued with great ardor. Amongst those who paid special attention to this duplicity, we again find some Jesuits, and their observations relate to the southern sky. Humboldt writes:† "* * * I there drew attention to the fact that α of the Southern Cross, * * * is one of those stars whose multiple nature was first recognized in 1681 and 1687 by the Jesuits Fontaney, Noël, and Richaud. * * * This early recognition of binary systems, long before that of ζ Ursæ Maj.‡ * * * is the more remarkable, as Lacaille, seventy years later, did not describe α Crucis as a double star * * * Richaud also discovered the binary character of α Centauri, almost simultaneously with that of α Crucis, and fully nineteen years before the voyage of Feuillée to whom Henderson erroneously attributed the discovery."

The Comets.

The comets also engaged the attention of the Jesuits. Fr. John B. Cysatus is worthy of especial mention in that he was

* The term companion or comes has since that time become standard.—Fr. J. S.

† Humboldt, Cosmos. vol. 3, p. 317, note.

‡ Probably not correct. For Riccioli noticed it already in 1650; perhaps it was noticed before, but I have no evidence.

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the first to use a telescope on a comet. It was the comet of 1618. He has published a paper on it, *Mathemata Astronomica* * * * Ingolstadii, 1619, which according to Wolf* "is justly numbered among the most important papers of former times concerning comets." A remarkable passage that occurs in it, has hitherto been overlooked. Wolf says† that Kepler and his contemporary Cysatus in their writings which appeared on occasion of the comet of 1618, already speak of a definite orbit, an almost straight one, of the comet, whilst until then comets were allowed to roam about in a lawless manner. However, Cysatus did not unconditionally trust the straightness of the path. He says that the path from the beginning of December until nearly the 7th of January corresponded to a straight line, but after that less so. "This curvature (of the orbit) would be a phenomenon of great importance, if it could be confirmed by more observations. For I will not come to a decision from the case of this one comet. For it is possible that on account of inadvertance the stars are not accurately plotted on the globe or that the observation of the comet's position in the line of the two fixed stars‡ (although accurately made) is really not so infallible. I therefore leave the case undecided."—The orbit was really not straight but elliptical, and it redounds to the honor of Cysatus that this small deviation from a straight line did not escape him in his observations.

Moreover Fr. Cysatus was the first thoroughly to study the structure of the comet, inasmuch as he was the first to apply the telescope to this purpose. He distinguished the nucleus and the coma in the head of the comet. Both terms remained in scientific usage. He says he had employed much diligence and much time in the work, and had made use of two tubes, one six, and the other nearly ten feet long.

He furnishes a very presentable description, one, in short, like those to be read today in text books of astronomy. Thus, for example, he says expressly that 1. the nucleus was visible, 2. there was a nebulous envelope about the nucleus, and 3. that outside of this envelope there was yet a luminous appearance, but considerably fainter, that therefore there were two brighter rings about the kernel. This may be the first observation referring to it, as it is perceptible only with a telescope, and no one had used the telescope upon comets before him.

* Wolf, Gesch. d. Astr. p. 409.

† Wolf ibidem, p. 410.

‡ He observed the comet's position by alignment.

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The extraordinary violent movements of the tail, and its retrograde lengthening and shortening (recounted by Littrow*), are also described in the observation of the 4th of December.

He always measured the diameter of the nucleus as well as of the coma. Once he saw in the coma a small star which he thought belonged to the nucleus; but in an hour and a half it developed into a fixed star by coming out of the coma.

Nebulae.

The same paper also contains the first account of the nebula of Orion, which he brings in as an explanation of the structure of the comet's head. "For the rest Bessel already spoke for the priority of Cysatus, and as his reclamation was little heeded I renewed the same," says Wolf.†—I add also that Cysatus was the first to mention not only the nebula of Orion, but even the so-called trapezium, that is, those stars that are compressed into a very narrow space in the nebula. This is a considerably more delicate discovery than that of the Orion nebula as a whole, and indeed only possible with the aid of a telescope, as Cysatus himself says: "for with the tube one sees, etc." This fact has hitherto remained entirely unknown. He says: "For the rest this appearance is like that of a crowding of stars near the last star in the sword of Orion; for with the tube one sees how in like manner some stars are compressed into a very narrow space, and how round about and between the stars a white light like that of a white cloud is poured out. This crowding of stars, I say, is very much like the head of the comet, only that it has somewhat more the form of a rectangle ("aliquanto oblongior")." It suffices to read this description, to contemplate the drawings of the head of the comet given in Cysatus's work, and to have seen the trapezium, in order to award the discovery of the trapezium at once to Fr. Cysatus.—The discovery of the trapezium is generally ascribed to Huygens, in as much as he declares it to consist of three close stars, to which he added a fourth in 1684; this may be corret, but that Cysatus has nevertheless seen the trapezium without determining the number of the stars, is beyond all doubt. He uses the expression "a few stars" instead of three or four; and as he declares this group of stars to be oblongior, he must have seen at least four stars; and this was as early as the year 1618.

* Wunder des Himmels, p. 565.

† Handbuch der Astr. I, 591.

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Furthermore, another fact has been overlooked (probably not been read, because it was in Latin; all this being contained in the thirteen lines* in which he refers to the Orion nebula),—that Cysatus mentions also another nebula, which is without doubt the one of which Littrow says: "(AR = 277° 35′, = D — 24° 0′, in Sagittarius), a very fine spherical group, gradually brighter towards the centre, but without a true nucleus. The stars of the 11th to the 15th magnitude appear to be equally distributed throughout, and the boundary of the whole indistinct. Discovered 1655 by Abraham Ile," Cysatus says: "Finally, another nebulous ball, set throughout with small stars, and a little above the arrow of Sagittarius, is also like the head of our comet." As he writes this in 1619, the priority must without doubt be ascribed to him.

The "Nebulosa" appear in general not to have been strangers to Cysatus, as he repeatedly speaks of the stellæ nebulosæ, without adding anything that might show them to be new.

In speaking of comets we must also add the name of Fr. Nicolas Sarrabat, who was the first to discover the comet of 1729, which is marked as a telescopic one. Consequently he was the first to discover a comet with the telescope.

The observation of the zodiacal light, this celestial interrogation point so very mysterious even today, frequently engaged the labors of Fr. Francis Noël (1729, missionary in China) and Fr. Esprit Pezenas, professor of hydrography in Marseilles, later director of the observatory in Avignon, who, according to Wolf,† in 1730 discovered the so-called counterglow (Gegenschein) of the zodiacal light.

Maps of Countries.

It yet remains for me to speak of geodesy and geography, in as far as they pre-suppose astronomical observations. The performances of the old Jesuits in this respect, we may say it boldly, are of extraordinary value. Let us first cast a glance at China, that immeasurably great empire. "In ten years work, says Dr. Wegener,‡ the Jesuits had to sift the rich, extant, and partially newly-made material, and to set it right and complete it by means of a large number of astronomical re-determinations, which they executed in extended journeys throughout the whole

* Mathemata Astronomica, p. 75.

† Handbuch der Astr. II., 504.

‡ Dr. Wegener in the Zeitschrift der Gesellschaft für Erdkunde in Berlin. XXVIII. 202.

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empire. The map, thus finished in the year 1718 and copies of it multiplied by means of a copper plate engraving, may unconditionally be put down as one of the greatest performances in the entire history of cartography. One must realize that an enormous area of eastern Asia was mapped upon it in more accurate detail than any one province of the small "Great Powers" of Europe at that time. The accuracy of the positions given upon the Jesuit map, at least in China proper, is so great, that modern deviations must always at first sight be considered with distrust. Thus, for example, the astronomical observations of the Széchényi expedition in the province Kansu proved the Jesuit positions to have been almost throughout more accurate than the deviations of Prshewalki."

Very much had already been done even before the definitive production of the map in 1718. "A decisive progress in the knowledge of China is connected with the appearance of the Jesuit Matteo Ricci, who obtained permission from the emperor in 1600 to make his permanent abode in Peking. Whatever views one may have concerning the political aims of that religious order, the history of the sciences can speak of the Fathers of Jesus only with wonder. Thus we are indebted amongst others to the Jesuit Martini, who returned from Asia to Europe in 1651, for the first atlas of China*, with which the newer knowledge of that empire begins. The Jesuits Grueber and Dorville reached Lhasa from Peking after a dangerous journey of six months, and from there descended to Agra over the Himalayas in 1661."† How many astronomical observations are contained in these few words and under what difficult circumstances!

To give only one example, Fr. Souciet, at the end of the first volume and as an appendix in the second volume, gives 218 positions, mostly from India, China, Thibet, amongst which are 111 from Fr. Gaubil, 89 from Fr. Noël. These are by no means all; but the enormous distances of the individual places sufficiently indicate what a value these determinations represent, as such long journeys through partially inhospitable regions and an unreliable population, journeys with the most primitive methods of conveyance, are by no means to be reckoned among pleasure trips. To these must be added many determinations of position in America, which probably brought many more difficulties along

* Novus Atlas Sinensis a Martino Martini S. J. appeared as the eleventh part of the Novus Atlas absolutissimus of Jansenius, 1655.—Martini was born in Trent.

† Peschel-Ruge, Geschichte der Erdkunde, Munich 1877.

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with them and were ascertained mostly only with the gnomon, as it was impossible to drag more instruments along. In this connection a remark inserted by its writer in the article, "Fr. Marquette,* Discoverer of the Mississippi River," is interesting. "For some reason that I am not able to explain, the Jesuit missionaries generally made a mistake of about a degree in their latitude determinations. Every point upon their maps, which are otherwise executed with wonderful accuracy for their circumstances, lies so much more to the south than upon the present maps." There is question of North America in the cited essay. Perhaps this circumstance that the latitudes are all too small by "about a degree," and that this error is constant although the observers are different, may be explained in this way, that many missionaries, who were by no means provided with refined measuring instruments, determined their latitudes by means of the gnomon and took meridian altitudes. They overlooked the fact that the umbral shadow of the gnomon indicates only the altitude of the Sun's upper limb, so that the angle of elevation becomes too great, and the latitude therefore as much too small.— As in China and America, so also in other countries the missionaries did their best to make themselves useful to science. Thus Stöcklein† says of Fr. Neret: "He measured the latitude of every place he visited with the quadrant that he carried with him, and laid off the meridian with his magnetic needle." He occupied himself principally with Syria. And the same author says about Fr. Sicard that the measurements from Pelusium to Suez, Memphis, Cairo, Ramasse * * * and Tur to Sinai, he obtained from Fr. Claudius Sicard, "who not only visited all these places, but also very accurately measured them with the compass and quadrant, and moreover, in regard to measuring the length of terrestial arcs, drew the first meridian arc * * * through the city of Paris."

We might yet mention the maps of the various countries which the Jesuits penetrated as missionaries. Thus the Benedictine Knogler‡ writes to v. Zach: "I have * * * all respect * * * for the Macartney map; but in regard to the Chinese Wall I cannot consider it correct. This I have much more accurately and in greater detail on a map of Tartary (more correctly Mongolia)

* "Alte und neue Welt," 1876, p. 646. Note 2.

† Allerhand So Lehr—als Geistreiche Brief, Schriften u. Reis—Beschreibungen, welche von denen Missionariis der Gesellschaft Jesu * * * in Europa angelangt sind. Augspurg und Grätz, 1728.

‡ Monatl. Korrespondenz, 1800, March, p. 247.

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executed by the Jesuits, which however is not engraved. On this the Wall looks very different. I can also send you a map of California drawn by the Jesuits." And v. Zach remarks hereupon: "Although the coasts of California have become more accurately known * * * since the observations of the latest circumnavigators, these older maps of the Jesuits may yet furnish a knowledge of the interior of the country which we do not up to the present possess, and therefore give a valuable contribution to the knowledge of countries." And Humboldt writes:* "Fr. Fritz had come to Quito with another German Jesuit, Fr: Richter; he drew up a map of the Amazon river in the year 1690, the best that could be had before La Condamine's journey." La Condamine himself, who travelled the same way, declares the map of the missionary Fritz to be "a valuable and unique piece, and one proving the ingenuity of its author." He there points out the enormous difficulties of the journey and the lack of instruments.

Equally remarkable and sensational was the map made by Fr. Francis Kino, born in Trent, apostle of Sonora in California, on which he drew the land route he had discovered to California in 1701, and thereby proved beyond doubt that California was a peninsula.

Fr. Adam Gilp (from Bohemia) designed a map of the province of Serres in the country of Sonora.

Fr. Liesganig superintended the construction of a large map of Galicia, consisting of 94 sheets, of which v. Zach says:† "The survey of Galicia was made under the direction of Liesganig (not without opposition on the part of some noble ignoramuses and surveyors) according to the well known and only true astronomical-trigonometrical method." At his side were the two Jesuits, George, baron of Mezburg and Francis Guessman. Mezburg later on conducted the survey of the west of Poland, that had been newly acquired, and began the map that Triesnecker completed. He also issued a postal map of the Austrian hereditary possessions. Fr. Christian Mayer did similar work. He published a "Charta geographica per tractum Rhenanum Moguntia Basileam usque."

The map of Carinthia by Fr. Charles Andrian, S. J., is also mentioned as a "beautiful and correct" one.‡

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* Humboldt's Travels to the Equinoctial Regions of America. Hauff's German Translation, vol. 5, p. 255. Stuttgart 1862.

† Monatl. Korresp. 1801 p. 554.

‡ Mitteil. des k. k. militärgeogr. Instituts. V. 1885 p. 152.

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Fr. Claudius Dechalles is also worthy of remark. As professor of hydrography in Marseilles "he there drew up a large map of the Mediterranean Sea resting upon astronomical observations, which was never indeed engraved but far surpassed the contemporary very erroneous maps."

In cartography mention must also be made of Fr. Nicasius Grammatici (1684-1736), of whom v. Zach reports:* "Nic. Grammatici of the Society of Jesus is known to all astronomers by his writings. * * * He deserves to be placed among the number of those astronomers whom we * * * have specially cited as being the first in the construction of geographical maps to have regard to the oblateness of the Earth and to recommend it to others."

While he may not independently have designed maps of countries, Fr. Ignatius Weinhart, professor of mathematics in Innsbruck, yet has rendered great service in this direction, as the famous "Bauernkarte" [Peasants' map] is, so to speak, due almost entirely to him.† For he had taught the Peasant Peter Anich surveying and the manufacture of suitable instruments, as well as making the necessary astronomical observations. Later on, after Anich had developed into a thorough geometer, Fr. Weinhart was authorized by the government to superintend Anich's survey of the Tyrol. In 1766 came the order "to take the Original-Mappam, as it had been designed by the late Peter Anich * * * and to copy it most accurately under the supervision of Professor Fr. Weinhart." For superintending and supervising the whole enterprise, Fr. Weinhart repeatedly received the highest acknowledgments and a medal of honor bearing the effigies of the empress and her consort.

Measurements of Terrestrial Arcs.

It yet remains to say a word about the measurements of terrestrial arcs. While the efforts of learned men at the end of the 17th century were being directed towards determining the size, and later on also the shape, of the Earth, the Jesuits also from that time on took a modest part in this by no means easy affair. Fr. Riccioli and Fr. Grimaldi in 1645 were the first to attempt the measurement of a degree of the meridian by means of mutual terrestrial zenith distances. It probably came out too large. For "this measurement of terrestrial zenith distances would be

* Monatliche Korrespondenz, Vol. I, p. 241. Note.

† Mitteilungen des k. k. militargeographischen Institutes. V. 1885, p. 106 seq.

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the simplest and best means of measuring the Earth if refraction did not exist or at least if it were more amenable to computation than has hitherto been the case."*

Upon this followed in the year 1702 the measurement of the arc which Fr. Anthony Thoma undertook in China and near Peking.† For it was in December 1702 that the emperor Kang-Hi ordered Fr. Thoma to measure a degree upon a large plain near Peking in company and with the co-operation of his third-born Prince, and in the presence of many mandarins of the Mathematical Tribunal. The presence of the imperial prince, who was himself a lover and connaisseur of mathematics, in which the Jesuits had educated him, and of the mandarins who were so very inimical to the European mathematicians, admits of our conjecturing with good reason that Fr. Thoma would not be wanting in diligence and in the exactitude of his measurements. The result is given in Chinese and also in old-Roman scale.

It is only the difficulty of reducing the unknown Chinese foot, and in like manner the old Roman foot, to the French scale that is in the way of our arriving at an exact knowledge of the result. Knogler,‡ who occupied himself with the case, took the mean of the lengths of the old Roman foot given by various writers in comparison with the French, and thus obtained a result that was only nearly 24 toises in excess of the one computed (in 1800) with the latest value of the ellipticity. However this is always very uncertain. There is a remarkable passage in Baron Richthofen in regard to this. He says that the Jesuits in China always endeavored to introduce a scale of measurement that was definite and easily comparable to the French, and that for the reason of being able to make their measurements more accurate, they concluded to put 200 Li equal to an equatorial degree. Kang-Hi established this as the official standard, and even at present it serves as the norm most frequently used for computation. The length of such a Li is 556.5 metres. Now 200 such Li are equal to 111,300m. But according to Jordan an equatorial degree is equal to 111,306.6m. No second arc measurement was undertaken in China, and as the establishment of this standard comes from the emperor Kang-Hi, there can be no doubt that the 200 Li = 111,300m. mentioned by Richthofen are deduced from this base measurement and seem to come very near to the truth.

* Handbuch der Vermessungskunde of Dr. W. Jordan. Stuttgart 1878. Vol. 2, p. 4.

† Monatl. Korrespondenz of v. Zach. 1800. March and June.

‡ Monatl. Korresp. Ibidem.

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For only two assumptions are possible: either at the computation of this equatorial degree the view of the French Academy at that time, which considered the Earth as a perfect sphere, was adopted, and then the value of the degree is about 140 toises too great, or Newton's oblateness (1/229) was used, and the truth was approached more closely. That the second assumption is the more probable appears from the expression "*equatorial* degree." which has no real meaning in the first assumption.

Upon this followed in 1775 the arc measurement of Fr. Boscovich and Fr. Maire and yielded a result which, according to Wolf,* "does all honor to the two geodetes, if we consider the instrumental means at their disposal." The occasion† of this measurement was "the want of agreement of the arc measurements of Peru, France and Lapland, which had led Boscovich to the idea that the Earth was perhaps not an ellipsoid of revolution * * * and that in order to answer this question it would be useful to measure another degree in the same latitude with the French one but in a different longitude. With the means then at hand, however, the measurements thereupon undertaken by him could impossibly lead to a decisive result * * *; on the other hand the train of thought of Boscovich, and especially the method, according to which he somewhat later on deduced the most probable value of the ellipticity (1/273) from the results of all the measurements accessible to him, represented for geodesy the dawn of a new day."

In regard to this arc measurement Wolf says:‡ "The sole important advance at that time was that at his arc measurement in the States of the Church Boscovich departed from the customary application of contact measurements * * * he then did not in practice bring the rods to a complete contact, but determined by means of a dividers and plotting scale the distance of the contiguous points."

It appears from the publications of the royal imperial military geographical institute¶ that Fr. Liesganig began the astronomical geodetic survey in Austria-Hungary in 1762. He undertook the measurement of a meridian arc at the command of the empress Maria Theresa. The apparatus constructed by Liesganig for the measurement of the base of the newer par[t] of Vienna

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* Wolf, Handbuch d. Astr. II, p. 193.

† Ibidem.

‡ Handbuch d. Astr. II. p. 15.

¶ 1884 p. 176 seq.

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served for such measurements until 1810. Gunther* remarks upon this: "Liesganig's work does not enjoy a particularly good reputation on account of its result, but it is not to be denied that its plan completely corresponds with the scientifico-technical norms that were considered the standards at that time; especially the considerations concerning the differences in the length of a Steyermarkian and of a Croatian degree, which are said to be conditioned by the attraction of the mountains, give no unfavorable testimony to the criticism of the learned Jesuit. His computations therefore must have been injuriously influenced by some constant errors of a particular kind."

Finally Fr. Christian Mayer measured a degree in the Palatinate, as he says in a certain publication.†

Published Works.

In conclusion yet a word about the literary activity of the Jesuits. Amongst the many works I call attention only to those that were considered important at their time and enjoyed praise or acknowledgment among the learned. I omit the various publications of the observations.

Amongst the astronomical writers the oldest of them must be named first. This is Clavius. Christopher Clavius, called the Euclid of his century, was born in Bamberg in 1538. At the age of 17 he entered the Society of Jesus, in which he distinguished himself in mathematics. Pope Gregory XIII made use of his knowledge for the reform of the calendar, which he had repeatedly to defend against many attacks. He died in Rome in 1612. Amongst his 26 works, of partly mathematical, partly astronomical contents, many of which passed through various editions and that in folio. I call attention to the following and add the judgment of Houzeau:‡

Commentarius in sphaeram Joannis a S. Bosco.—"This treatise is the best commentary ever written on the astronomy of Sacrobosco."

Gnomonica libri 8 * * * 1581.—"This is the greatest work on gnomonics that exists, a work that may be considered an encyclopedia of skiatherics."

Rom. Calendarii a Gregorio XIII. restituti explicatio 1603.

* Günther, Lehrbuch der Geophysik u. phys. Astronomie. Stuttgart 1884, Vol. 1, p. 144. Note.

† Basis Palatina * * * exeunte aune 1762 ad normam Academiae regiae Parisinae scientiarum exactam bis dimensa * * * a Chr. Mayer, S. J.

‡ Houzeau Vademecum de l' Astronomie, p. 110.

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"Gives the completest idea of the elements of the Gregorian reform."

Next there are some noteworthy works on Chinese astronomy. To these belong Fr. Gaubil's Traité de l'Astronomie chinoise, "an important work."* Then Liber organicus by Fr. Verbiest, but especially his "Astronomia europea sub imperatore * * * Cam Hi * * * in lucem revocata * * * Dilingæ 1687." "This book is necessary for those who wish to learn the astronomy of the Chinese."† These are the most important among the many works on astronomy in China. We might also mention the various star tables, edited with Chinese text by the Jesuits, especially the planispheres, which were published after a work of Fr. Pardies and contain star positions projected upon the faces of a cube circumscribing a sphere. Fr. Pardies had invented this method of projection.

J. B. Riccioli (Ferrara 1598, Bologna 1671) published various works on astronomy, but the most important is his Almagestum novum * * * Bononiæ 1653. Fol. and Astronomia reformata * * * Bononiæ 1655. Let us first listen to the weighty judgment of v. Littrow on Riccioli: "The well known Jesuit Riccioli has occupied himself very much with the Moon and with the whole of astronomy generally, without however thereby advancing this science very much."‡ Very flattering! J. C. Houzeau in his Vademecum de l' Astronomie (p. 116) entertains a somewhat different view when he writes: "Riccioli Almagestum novum. This immense work, a treasure of astronomical learning, forms a veritable encyclopedia of the science of the stars." And "Astronomiæ reformatæ tomi 2. The collection of observations, which forms the tenth and last book, is a valuable source." An old savant had called the Almagestum novum the pandects of astronomical knowledge.¶ It seems therefore that v. Littrow has accidentally overlooked these two works or not known of their existence.‖ The object of this colossal work is given by Riccioli

* Houzeau, p. 44.

† Houzeau p. 44.

‡ Die Wunder des Himmels, 7th edition, p. 401.

¶ Morhof Polyhistor, t. II, vol. II, p. 347.

‖ [Compare Newcomb's vindication of Hell against the misrepresentations of Littrow in the Astronomical Papers of the American Ephemeris, vol. II, pp. 301, 302: "The conclusion was reached that Littrow's inferences were entirely at fault * * * Littrow's mistakes were due to the fact that he was *color-blind to red*, in consequence of which he wholly misjudged the case on first examining the manuscript, and afterward saw everything from the point of view of a prosecuting attorney."—Transl.]

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himself in the preface with sufficient explanation. He intends to offer "an astronomical work, which may be a kind of library for the men of our Society and for others who cannot have access to the great number of such books or the leisure to read them, a work, in which I have collected with the greatest clearness the whole of the old and the new astronomy, together with the controversies that occur therein." The work becomes yet more valuable on account of a personal index, used perhaps for the first time, in which nearly all the persons mentioned in the book are recounted and accompanied by the data of their lives. The work also contains a number of accurately stated observations made by himself as well as by others.

Maximilian Hell, a Hungarian, born 1720, died 1792. When Maria Theresa in the year 1756 erected the observatory at the Vienna university, Hell was called to be its director on account of his attainments, and remained in this position during 35 years until the end of his life. A call to England with a considerable salary, which he received at the time of the Suppression of the Society, he declined. Amongst the many works that he published the ephemerides deserve particular mention. This was the first undertaking of its kind after the Connaissance des temps, the first therefore in German countries.

The ephemerides appeared each year and always contained appendices, that is, treatises on various astronomical subjects. The first were published from 1757 until 1792; from that time on Fr. Francis Triesnecker undertook their continuance until the year 1806. Triesnecker himself wrote astronomical works and treatises; but perhaps it redounds more to his praise that he "was an unselfish astronomical computer,"* who at once used the many observations of occultations reported to him for the determination of positions (in longitude).

Roger Boscovich (Ragusa 1711, Milan 1787) might also be mentioned. Amongst the nearly 70 publications of this genial man, of partly mathematical, partly astronomical contents, there are many very excellent ones, as for example, the one on gravitation; again, about comets "de orbitis cometarum determinandis 1774;" and "De annuis fixarum aberrationibus," in which he gives formulæ for the change of position caused by parallax and refraction. All these works Houzeau mentions in an especial manner.

May these few works among the many suffice to show that the

* Wolf, Handbuch d Astr. II, p. 311.

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old Jesuits have produced something worthy of mention in astronomical literature.

With this I deem my task accomplished, in that I have briefly shown the intimate relationship of the old Jesuits to astronomy, principally by recounting their observatories, by giving their performances in respect to astronomical instruments, their more remarkable observations, some priorities especially, their application of astronomy to cartography and arc measurements, and finally by mentioning some of their numerous astronomical writings. I believe the activity of the Society of Jesus in this field will not be undervalued, but it will be acknowledged that she has done much for her circumstances. To present this truth in its proper light, was also the purpose of these lines.

THE SUN'S MOTION REFERRED TO A GROUP OF FAINT STARS.

GEORGE C. COMSTOCK.*

A year ago I presented to this Society a set of proper motions of faint stars (ninth to twelfth magnitude, distributed throughout the twenty-four hours of right ascension) determined from micrometric observations extending over a period of about half a century. During the past year I have derived from these proper motions a determination of the direction and magnitude of the Sun's motion using Airy's method for the formation of the necessary equations. This method requires that some assumption shall be made with regard to the distance of each star employed and for this purpose I have used an extrapolation of Kapteyn's formula which represents this distance as a function of the proper motion and stellar magnitude.

I have thus derived from absolutely new data, no one of the proper motions employed having entered into any previous investigation, the following co-ordinates of the apex of the solar motion:

$$\text{R. A.} = 297^\circ \qquad \text{Decl.} = +\ 28^\circ$$

The mean result of previous determinations from brighter stars is R. A. = 275°, Decl. = + 30°. My solution furnishes as the linear velocity of the Sun's motion 4.8 radii of the Earth's orbit per annum, which compared with Campbell's spectroscopic result, 4.2 radii per annum, indicates that the assumed parallaxes

* Read at the meeting of the Astronomical and Astro-Physical Society of America, St. Louis, Dec. 30, 1903.

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